The Efficiency of Tools Used To Retract a Football Helmet Face Mask

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Objective: The purpose of this study was to evaluate time, head movement, and ratings of satisfaction with several popular tools used for retracting a football helmet face mask.

Design and Setting: Subjects retracted the face mask using a Phillips screwdriver, a Trainer's Angel, and an anvil pruner. A utility knife had to be eliminated from the study after the first two subjects were injured.

Subjects: Five certified athletic trainers, five emergency medical technicians, and five student athletic trainers retracted a face mask with each tool.

Measurements: Time was measured by stopwatch and movement by a force platform. Efficiency was calculated from total time and radial area. Ratings of satisfaction were reported by the subjects.

Results: There was no difference in the total time to retract the face mask using the three tools. Movement was significantly ($p < .05$) greater with the Trainer's Angel than with the anvil pruner or screwdriver. Subjects were more satisfied with the anvil pruner than the Trainer's Angel or screwdriver. When grouped by the subjects' credentials, there were no differences in time or rating of satisfaction among the certified athletic trainers, emergency medical technicians, or student athletic trainers, but there was a difference for movement. The student athletic trainers produced the least movement and the certified athletic trainers produced the most.

Conclusions: It is suggested that the skill of face mask retraction be learned and practiced.

Key Words: loop straps, first aid, athletic injury, safety equipment

The current practice in the management of an injured football player with a suspected spinal injury is not to remove the football helmet.[1–4] Certified athletic trainers (ATCs) are instructed to remove or retract only the face mask to gain access to the athlete's airway. Often, however, the standard operating procedure for emergency medical technicians (EMTs) is to remove the helmet completely.[1,5] One possible reason for this difference in protocols and training may be that EMTs are confronted with a similar situation in the event of a motorcycle accident.[6] In this instance, there being no alternative methods for gaining access to the victim's airway, the helmet must be removed.

The design of the football helmet, however, is quite different from that of a motorcycle helmet. The face mask of the football helmet is secured to the helmet with four plastic loop straps that can be cut or removed, thus allowing the face mask to be retracted or removed.[7] When the two lateral loop straps are cut or removed, the face mask can be retracted or "swung away," using the two anterior loop straps as a hinge.[1,2,8,9] This design enables medical personnel to gain access to the airway and vital areas of the face for examination and to administer emergency care to the athlete without having to remove the helmet. It is also important that the helmet not be removed unless the shoulder pads are removed simultaneously to limit movement. Reducing movement of the athlete's head and neck is of primary importance since it is believed that any additional movement that occurs during face mask retraction can cause further damage to the athlete with an injury to the cervical spine.[1,3]

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Several tools have been mentioned in the literature that may be used to remove the loop straps that secure the face mask to the helmet;[2,4,9–13] however, little research has examined the amount of head and neck movement that occurs during face mask retraction with these various tools. Thus, many of the suggestions that have been proposed regarding which tool might be best have little or no scientific foundation related to the athlete's safety.

One method mentioned for face mask removal or retraction is to remove the loop straps with a screwdriver (SD). This seems logical since the loop straps are fastened to the helmet by a T-bolt, a washer, and a screw; however, during the length of a football season moisture can rust the screws and T-bolts, making them difficult to remove with a screwdriver.[9] In other cases, the T-bolt holding the screw can turn as the screw is being removed. Hence, the effectiveness of a screwdriver is limited and unreliable.

Another recommendation is to use a sharp knife, scalpel, or utility knife to cut the loop straps.[9,14,15] The problem with using a sharp tool to cut the loop straps is that athletic trainers may slip and cut athletes or themselves.[9,12] There also may be excessive movement of the head and neck if the athletic trainer slips while trying to cut the straps.[15] Furthermore, loop straps are now made of harder materials that make them more difficult to cut.[12]

It has also been suggested that a spring-loaded anvil pruner (AP) (Fig 1), a wire cutter, or a ratcheted PVC pipe cutter be used to remove the loop straps.[9,15]

Currently, the most popular and widely used tool for face mask retraction is the Trainer's Angel (TA) (Trainer's Angel, Riverside, CA).[2,10] In one study,[10] 54% of the ATCs who were surveyed ($n = 50$) reported that the TA is the tool that they carry for face mask retraction. The TA is the only tool

Fig 1. The anvil pruner.

currently available that is specifically designed to cut the loop straps that secure the face mask to the helmet.

The purpose of this study was to compare the tools used for face mask retraction for the time that it takes to remove the loop straps and the resulting amount of head movement. This study also attempted to identify the subjects' satisfaction with the various tools and whether the subjects' experience or training influenced their ability to retract the face mask.

METHODS

Five entry-level student athletic trainers (SATs) with less than 100 hours of athletic training clinical experience volunteered to participate in this study. Five EMTs and five ATCs with experience providing medical services to football players also volunteered to participate in this study. In addition, one subject volunteered to serve as a model representing an unconscious football player with a suspected cervical spinal injury. Each subject used the three tools to retract the face mask in random order. The tools used in this study were a Phillips screwdriver (SD), a TA, and a modified AP. The AP was modified by shaving the anvil block to make the tip concave to match the convex shape of the face mask bar. This enabled the AP to rest on the face mask bar while cutting the loop strap (Fig 2).

Fig 2. The anvil pruner cutting a loop strap where the modified anvil block is resting on the face mask bar.

After viewing videotaped instructions and a demonstration of the proper technique for using each tool, subjects were given time to familiarize themselves with the tools and allowed to practice cutting previously discarded loop straps. The subject was then escorted to a different room where the model was already lying on a force platform covered with artificial turf.

The model was fitted with shoulder pads and a football helmet to which the face mask was secured by four Schutt (Litchfield, IL) ArmorGuard polyethylene loop straps. The model was lying supine with his head placed on a force platform. The center of pressure was calculated from the force platform data and was used to describe head movement. From the center-of-pressure data, the radial area was calculated (cm^2), as well as the average movement and velocity along the x-axis and y-axis (cm and cm/sec, respectively). The force platform data were sampled at a rate of 50 Hz. Electromyographic surface electrodes were attached to the model's left and right sternocleidomastoid and upper trapezius muscles. Electromyographic data were sampled at a rate of 200 Hz and were examined to ensure that the model neither assisted nor resisted the subject's attempts to stabilize his head while retracting the face mask.

One of the three tools was placed next to the model's helmet in random order. The subject picked up the tool and retracted the face mask by cutting or removing the two lateral loop straps and then retracting or "swinging away" the face mask using the two anterior loop straps as a hinge. The subjects were instructed to retract the face mask quickly and with as little movement to the model's head as possible.

Two independent investigators used a stopwatch, recorded to the nearest tenth of one second, to determine the time that it took to complete the task. Data collection began when the subject picked up the tool to begin the trial and ended when the face mask was fully retracted. Time data were divided into three phases: time to cut or remove the two lower loop straps, time to retract the face mask, and total time for retraction (sum of the first two variables). The three times were used to gain a better understanding of the efficiency of each tool. It is possible that total time could be similar among tools, but that one tool could take longer to cut or remove the loop straps, while taking less time to retract the face mask. While that information may not appear to be clinically relevant, it is very important in the design of new tools.

After each trial, the subjects were also instructed to rate their satisfaction with the tool (ie, comfort of the tool, ease of using the tool, and their effectiveness in using the tool) on a ten-point scale. The face mask was then replaced with new hardware and the procedure was repeated for the other two trials.

A score of efficiency was calculated by the investigators ($s \times cm^2 \div 10$, where s = time and cm^2 = movement) and was used to describe both time and movement.

A mixed factor (tool $\times$ training) analysis of variance (ANOVA) with repeated measures was used to test for significance between tools and qualifications. Tukey's post hoc test was used to determine any individual differences among significant main effects. The data are presented as means ($\pm$ standard deviation). The level of significance was set at $p < .05$.

RESULTS

Time Data

The time to retract the face mask was separated into three categories: time to cut or remove the loop straps, time to retract the face mask after the loop straps were cut or removed, and total time. Analysis showed no significant difference ($F(2,24) = 0.74$, $p = .486$) in the time for total retraction using the three tools. However, significant differences were identified when the total time was separated into its components of time to cut or remove the loop straps and time to retract the face mask ($F(2,24) = 3.61$, $p < .05$, and $F(2,24) = 6.24$, $p < .05$, respectively).

The analysis of the time that it took to cut or remove the loop straps demonstrated a significant tool effect (Table 1). Post hoc evaluation revealed that the times for the AP and TA were significantly different from the times for the SD, with means of 31.22 (± 22.19), 31.63 (± 14.46), and 41.55 (± 10.32) seconds, respectively.

Once the loop straps were cut or removed, the time it took to retract the face mask was also analyzed. A significant difference was again present among the means of the different tools (Table 1). The AP (22.32 ± 14.20 seconds) took significantly longer to retract the face mask than the SD (7.57 ± 4.50 seconds) or the TA (13.39 ± 11.78 seconds).

Analysis showed no difference in the mean amount of time that it took for total retraction using the three tools: 49.12 (± 10.46), 45.02 (± 19.39), and 53.53 (± 32.39) seconds for SD, TA, and AP, respectively (Table 1).

Movement Data

No electromyographic activity was observed from the surface electrodes placed on the model, indicating that the model neither assisted nor resisted the subject. Thus, all movement data reported herein were attributed to the subject or tool as a direct result of retracting the face mask. The analysis of the radial area of the center of pressure on the force platform showed a significant ($F(2,24) = 7.07$, $p < .05$) tool effect among SD, TA, and AP (1.03 (± 0.87), 2.52 (± 1.27), and 2.04 (± 1.00) cm^2, respectively). Post hoc tests revealed that the mean data from the TA were significantly greater than the data from the AP and the SD, with no difference between the data from AP and SD (Table 2).

The analysis of the X deviation only, reflecting neck lateral rotation, revealed no significant difference ($F(2,24) = 2.76$, $p = .085$) among the tools: 1.75 (± 0.75), 2.22 (± 1.13), and 1.84 (± 0.92) cm, for SD, TA, and AP, respectively (Table 2). However, the analysis of the Y deviation alone, reflecting flexion and extension of the neck, demonstrated a significant tool effect ($F(2,24) = 4.14$, $p < .05$) with the TA being significantly greater than the SD, with values of 3.48 (± 1.52), 4.72 (± 2.41), and 3.99 (± 1.82) cm, for SD, TA, and AP, respectively (Table 2).

Rating of Satisfaction

The data revealed that a significant difference ($F(2,24) = 7.43$, $p < .05$) existed for the subjects' ratings of satisfaction among the SD, TA, and AP, with mean ratings of 3.8 (± 2.5), 4.5 (± 2.3), and 6.9 (± 1.7), respectively (Fig 3). The AP was rated significantly better than the SD and TA, although no difference existed between the SD and the TA.

Efficiency

Efficiency data were not statistically different from each other ($F(2,30) = 2.35$, $p = .114$). A lower efficiency score meant the tool was more efficient. Mean scores were 12.29 (± 10.25), 9.43 (± 6.84), and 8.22 (± 5.39), for the TA, AP, and SD, respectively (Fig 4).

Effects of Credentials

There were no significant differences among the three groups of subjects (SATs, ATCs, and EMTs) for any of the time variables ($F(2,12) = 0.10$, $p = .903$; $F(2,12) = 0.16$, $p = .856$; and $F(2,12) = 0.05$, $p = .952$, for cutting or removing, retraction, and total time, respectively). Mean times to completely retract the face mask were 51.1 (± 22.2), 48.5 (± 17.8), and 48.1 (± 20.7) seconds for SATs, ATCs, and EMTs, respectively. Time data are presented in Table 1.

The analysis did reveal a significant ($F(2,12) = 7.08$, $p < .05$) group effect for movement (radial area) among SATs, ATCs, and EMTs, with values of 1.18 (± 1.06), 2.91 (± 0.77), and 1.98 (± 0.58) cm^2, respectively. Tukey's post hoc test

Table 1. Mean (± standard deviation) Time To Remove the Face Mask by Tool and Group

Tool	Credential	Time To Cut or Remove Loop Strap (sec)*	Time for Retraction (sec)*	Total Time (sec)
SD*	SAT	42.84 (9.72)	6.19 (3.54)	49.03 (10.88)
	ATC	41.07 (13.48)	7.29 (3.73)	48.36 (13.24)
	EMT	40.74 (9.68)	9.24 (6.19)	49.97 (9.38)
TA*	SAT	27.98 (11.51)	8.00 (5.46)	35.98 (16.56)
	ATC	36.57 (15.04)	17.55 (18.63)	54.13 (25.28)
	EMT	30.35 (17.99)	14.61 (7.00)	44.96 (14.04)
AP*	SAT	39.83 (23.82)	28.54 (16.12)	68.37 (39.00)
	ATC	21.26 (7.74)	21.80 (15.63)	43.06 (14.89)
	EMT	32.56 (29.62)	16.61 (10.56)	49.17 (38.65)

* Indicates a significant ($p < .05$) difference between groups.

Table 2. Mean (± standard deviation) Movement by Tool and Group

Tool	Credential	X Deviation (cm)	Y Deviation (cm)*	Radial Area (cm^2)*
SD*	SAT	1.13 (0.93)	2.03 (1.70)	1.03 (0.87)
	ATC	2.40 (0.47)	4.56 (0.90)	2.46 (0.76)
	EMT	1.60 (0.08)	3.57 (0.98)	1.45 (0.25)
TA*	SAT	1.49 (1.39)	2.81 (2.94)	1.32 (1.27)
	ATC	2.93 (1.20)	6.00 (2.10)	3.39 (0.94)
	EMT	2.10 (0.30)	4.96 (1.50)	2.60 (0.84)
AP*	SAT	1.32 (1.22)	2.67 (2.44)	1.20 (1.04)
	ATC	2.72 (0.23)	5.54 (0.65)	2.87 (0.61)
	EMT	1.39 (0.33)	3.49 (0.88)	1.89 (0.65)

* Indicates a significant ($p < .05$) difference between groups.

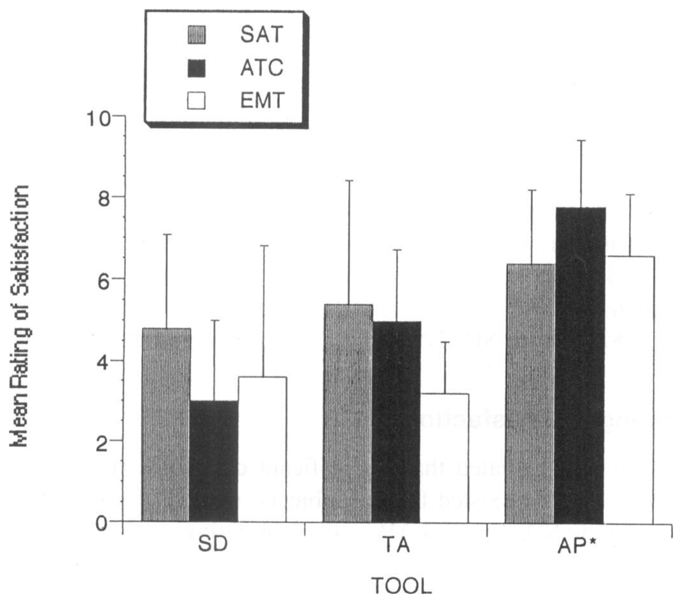

Fig 3. Mean (± standard deviation) subjective ratings of satisfaction by tool and group. * indicates a significant ($p < .05$) difference between groups.

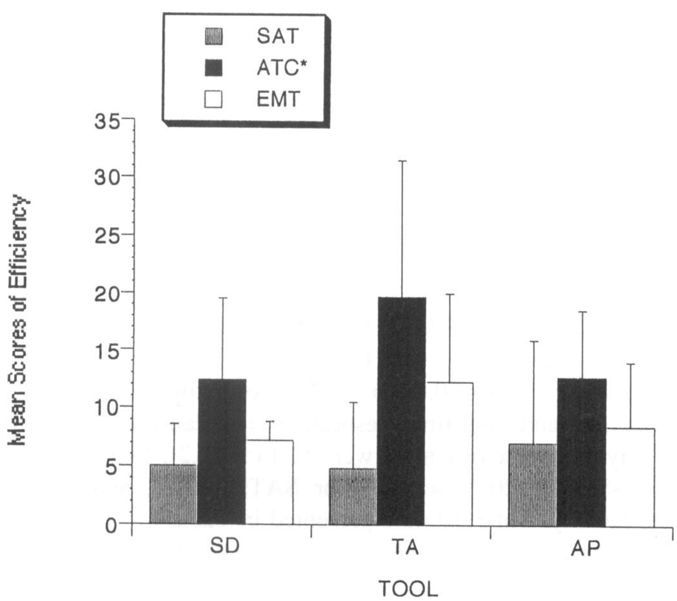

Fig 4. Mean (± standard deviation) scores of efficiency by tool and group. * indicates a significant ($p < .05$) difference between groups.

demonstrated that the radial area of the center of pressure from the ATCs was significantly higher than that from the SATs. No differences existed between the SATs and EMTs or between the ATCs and EMTs. Further analysis revealed that the ATCs caused significantly more movement in the X ($F(2,12) = 5.49$, $p < .05$) and Y ($F(2,12) = 4.72$, $p < .05$) directions than the SATs. No difference existed between the SATs and EMTs or between the ATCs and EMTs for either X or Y movement.

Rating of satisfaction was not different among experience levels ($F(2,12) = 1.35$, $p = .296$). Mean values were 5.27 (± 2.63), 4.47 (± 2.56), and 5.53 (± 2.42) for ATCs, EMTs, and SATs, respectively (Fig 3).

Efficiency data showed the ATCs to be the least efficient group (the EMTs being more efficient and the SATs being most efficient), with scores of 14.95 (± 8.70), 9.32 (± 5.62), and 4.38 (± 4.18), respectively. The ATC data were significantly different ($F(2,30) = 8.41$, $p < .05$) from the data of the other two groups (Fig 4).

DISCUSSION

The original purpose of the study was to compare four different tools (SD, TA, AP, and a utility knife) for their efficiency at removing the loop straps that secure the face mask to a football helmet. However, the utility knife had to be eliminated from the study after the first two subjects (one ATC and one SAT) were injured while using the tool. The data from those subjects were withdrawn.

The results indicated that it took longer for the SD to remove the loop straps than it did for the TA or the AP to cut the loop straps. However, it took significantly less time to retract the face mask when the loop straps were removed with the SD than it took when the loop straps were cut with the TA or AP, illustrating the importance of measuring cutting or removal times, retraction times, and total retraction times. These data suggest that it does not take any longer to retract the face mask with the SD than it takes with the TA or AP and that less head and neck movement may occur while doing so.

Another ATC had to be replaced (and his data withdrawn) after he damaged the screw and failed to remove the loop strap using the SD. During this trial the ATC was unable to remove the screw, because the T-bolt in the back of the helmet began to spin along with the screw. The ATC tried to remove the upper two loop straps, but again the T-bolt began to spin. The trial was ended when it became apparent that the SD would not be able to remove the screw, this only after several unsuccessful attempts had been recorded. If the SD failed to remove the loop strap under these ideal conditions (a quiet, environmentally controlled laboratory with new screws and T-bolts), then it cannot be considered a reliable tool for use in the field. If rescuers had no other tools available for retracting the face mask, then they would be forced to remove the helmet and place the athlete at further risk for injury. Thus, we suggest that if the medical personnel wish to continue to use a SD to remove the loop straps, then it is important for another tool to be readily available in the event that the SD fails.

Significant differences were found when the total time to retract the face mask was segmented into time to remove or cut the loop straps and time to retract the face mask. This study demonstrated that the subjects using AP and TA were significantly faster in cutting the loop straps than were the subjects using the SD to remove the screw and the entire strap. Once the loop straps were cut or removed, the trials for the subjects using the AP took longer to retract the face mask than did the trials for the subjects using the TA and SD. This would indicate that subjects had difficulty maneuvering the face mask around the residual loop strap attachments once they had been cut. With the SD there was little chance for the face mask to become caught on any residual strap while being retracted, since the loop straps were removed in their entirety.

Several assumptions were made in using the force platform data to determine head movement. The first assumption was that the movement of the head reflects the movement in the spine. In this study, the radial area of the helmet moving on the force platform was used as an estimate of movement in the cervical spine region. Since the helmet was properly fitted, any movement of the helmet should have reflected movement of the model's head. The maximum amount of head movement that can be inflicted by the rescuer without causing further damage to the athlete has not yet been determined. Therefore, it is not known whether the values recorded in this experiment would have been above or below this hypothetical threshold. The literature states that, when a neck injury occurs, if the cervical spine is moved as little as 1 mm there is an increased risk of causing further damage to the athlete.[16] The values recorded in this experiment can be compared only among groups, and no conclusions should be drawn as to whether the amount of movement that occurred was safe. The general principle is to cause as little movement as possible to the head and neck of an individual suspected of having a cervical injury. Using this theory, the tool and group that caused the least amount of head movement would be more desirable.

One possible reason for the difference in movement between the ATCs and the SATs was that the ATCs could have been more concerned with retracting the face mask quickly, whereas it appeared that the SATs were more concerned about the amount of movement and took greater caution while cutting the loop straps. Even though there were no differences in the time it took to retract the face mask, there was a difference in the amount of head movement. The difference in the model's head movement may have occurred because the SATs made better cuts than did the ATCs. When the times for retraction data were compared, it showed that the SATs took only 8.00 ± 5.46 seconds to retract the face mask after the cuts were made with the TA, while the ATCs took 17.55 ± 18.63 seconds to retract the face mask. It would appear that the ATCs had a more difficult time in retracting the face mask for this condition than did the SATs. However, since each group of subjects was such a small sample, these data may not be a true representation of the population. In addition, the use of only one rescuer could be considered a limitation of our study. We purposefully chose not to have two rescuers in our study to avoid introducing either a confounding variable or any influence the second rescuer might have had on the results. Additionally, the subjects in this study were not permitted to use their knees to stabilize the model's head since use of the knees would have interfered with the collection of data on the force platform. We believe that it is possible for athletic trainers to be required to retract a face mask without having qualified assistance in stabilizing the head. We do not believe that having only one rescuer detracted from the purpose of this study, which was to evaluate differences between tools and subjects' qualifications.

The efficiency data are important because of the limited number of investigations that have evaluated time and movement together. Efficient retraction of the face mask must include both time and movement components.

CONCLUSIONS

Several conclusions can be drawn from this study. First, this study demonstrated a difference in tools that warrants further research. In this experiment the utility knife was found to be unsafe; it should not be used for retracting a face mask. The SD can be a good tool with regard to limiting movement, but it proved to be unreliable. The AP showed promise, but a proper technique for cutting the loop straps must be employed to increase efficiency. In this study, the TA was not very impressive and produced more movement than any other tool. Our data also revealed a difference in subject groups, with ATCs allowing the most movement and, as a result, being the least efficient. Retracting the face mask carefully is as important as retracting it quickly. Certified athletic trainers are not automatically proficient in face mask retraction by virtue of their certification. In conclusion, we agree with the recommendation to retract or remove only the face mask and not to remove the helmet itself. However, we believe that additional research is needed in the area of face mask retraction and removal. We suggest that current protocols undergo more scientific validation and that new protocols and new tools be based on efficiency. Lastly, it is hoped that this study will promote greater awareness of the potential problems that can occur when retracting a football helmet face mask. Face mask retraction is a skill that must be learned and practiced.

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